

NATIONAL PROFESSIONAL EXAMINATIONS

DECEMBER 2009

98-MMP- A3 - Mineral Processing

DURATION : 3 hours

NOTES:

- (1) This is a CLOSED BOOK EXAM. No notes or textbooks permitted.
- (2) Candidates may use one of the approved Casio or Sharp calculators.
- (3) Answer all questions except where otherwise noted, i.e. in Problem 7.
- (4) Show all calculations.
- (5) Page 6 is to be handed in with the examination booklet
- (6) If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
- (7) The mark distribution is as follows:

Problem 1 (a) 12 (b) 8 Total 20 marks

Problem 2 (a) 9 (b) 4 (c) 4 Total 17 marks

Problem 3 (a) 4 (b) 4 Total 8 marks

Problem 4 Graph 5 marks (a) 3 (b) 3 (c) 4 Total 15 marks

Problem 5 Total 5 marks

Problem 6 Total 5 marks

Problem 7 Five marks for each part Total 30 marks

Bonus Question 2 marks

Unit conversions:

1 tonne = 1000kg = 2202.6 lb

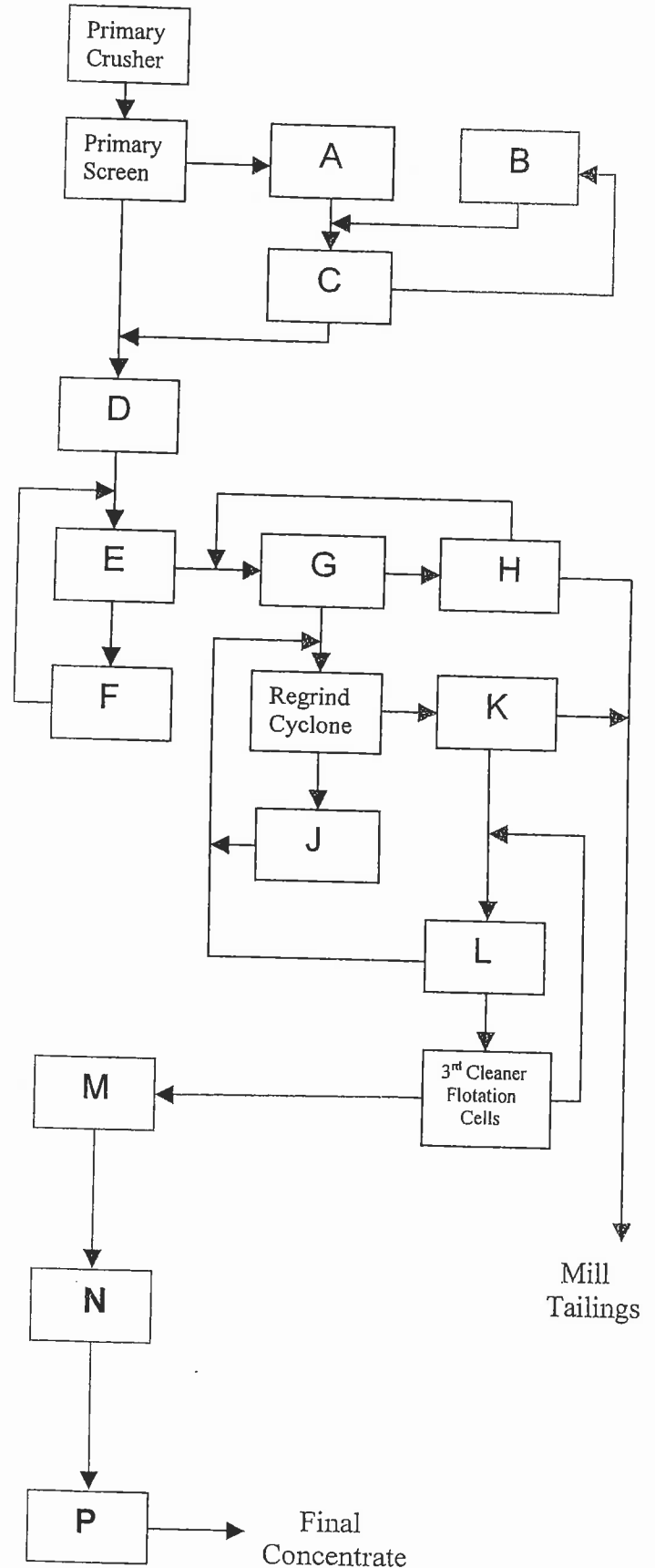
1 ton = 2000 lb

1 inch = 2.54 cm = 25,400 microns (μm)

PROBLEM 1 (20 Marks)

(a) Shown to the right is the flowsheet of the Bell concentrator which operated in central British Columbia from 1972 to 1992. The mill processed 13,000 tpd of ore from an open pit mine to produce a copper concentrate. Identify the unit operations which best fit into the flowsheet at the appropriate locations from A to P. Select the unit operations from the list below.

- thickener*
- secondary screen*
- scavenger flotation cells*
- ball mill*
- 1st stage cleaner flotation cells*
- tertiary crusher*
- hydrocyclones*
- regrind ball mill*
- dryer*
- rougher flotation cells*
- 2nd stage cleaner flotation cells*
- filter*
- secondary crusher*
- rod mill*



Problem 1 Continued

(b) If the copper content of the solid streams at the Bell concentrator were:

- Mill feed 0.5% Cu
- Tailings 0.05% Cu
- Concentrate 30.0 % Cu

Calculate the tpd of copper concentrate produced.

Problem 2

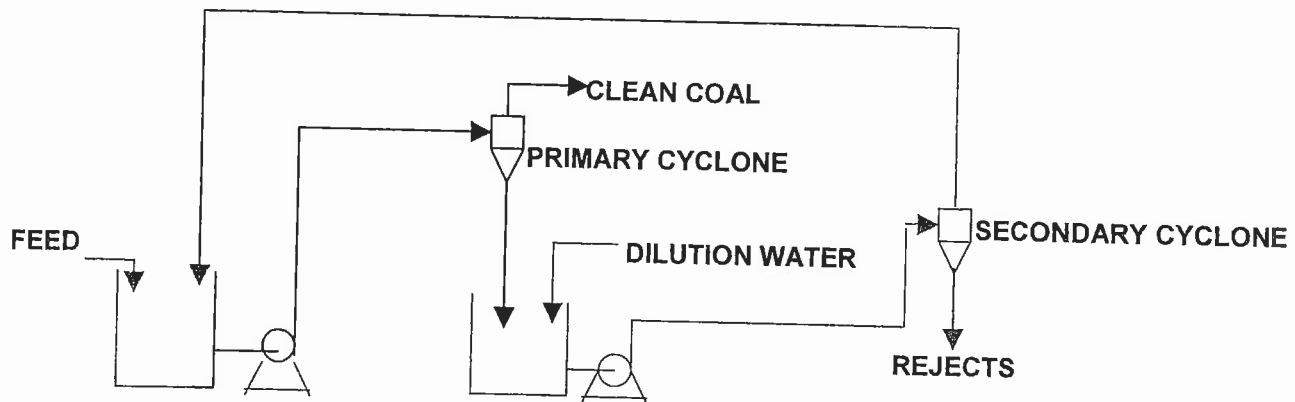


FIGURE 1. Layout of Coal Cleaning Circuit for Problem 2

A two-stage automedium (water only) cyclone circuit is used for cleaning 80 tonnes/hour of fine coal as illustrated in Figure 1. The circuit was sampled and the results were as follows:

	Percent <u>Solids</u>	Percent <u>Ash</u>
Circuit feed	12.5	25
Primary Cyclone Feed	13.16	25
Primary Cyclone Overflow (clean coal)	10.00	10
Primary Cyclone Underflow	25.00	47.5
Secondary Cyclone Overflow	16.67	25
Secondary Cyclone Underflow (rejects)	33.33	70

(a) Carry out a material balance and calculate the tonnes/hour of clean coal produced by the circuit.

(b) Calculate the tonnes/hour of dilution water added to the sump. **(4 marks)** **(9 marks)**

(c) Calculate the tonnes/hour of solids in the primary cyclone underflow. **(4 marks)**

Problem 3. (8 marks).

A flotation kinetics test was carried out on an oil sands sample. The results were as follows.

<u>Flotation Time Minutes</u>	<u>Bitumen Recovery</u>
1	60%
12	90%

Assuming that the flotation follows the following first order rate equation:

$$R = RI [1 - \exp(-kt)]$$

- (a) Using the available data determine the parameters RI and k.
- (b) Determine the flotation time required to achieve an 80% recovery.

Problem 4. (15 marks).

Given that a sieve analysis was carried out on the flotation feed in the Bell concentrator described in Problem 1 with the results as follows:

<u>Size Microns</u>	<u>Weight g</u>
+425	17
-425+300	31
-300+212	24
-212+150	19
-150+106	15
-106+75	12
-75	42

Using the log-log graph paper provided on page six, plot the Cumulative Weight Percent Passing versus the Particle Size in microns. From the plot determine:

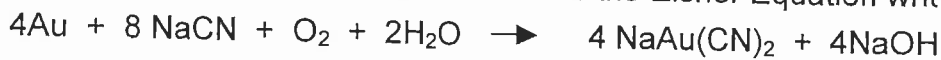
- (a) the mass median size (50% passing size) in microns
- (b) the estimated percentage of material in the -75+37 micron fraction
- (c) using Bond's equation calculate the net power (kilowatts) required for comminution of the Bell copper ore. Assume a work index of 12, a relatively large feed size and a 24 hour day.

Bond's Equation:

$$W = \frac{10W_i}{\sqrt{P}} - \frac{10W_i}{\sqrt{F}}$$

Problem 5 (5 marks)

It is generally accepted that gold reacts with cyanide to form a water-soluble gold aurocyanide complex according to a chemical reaction known as the Elsner Equation written as follows:



Briefly describe two methods used by the mining industry to recover the dissolved gold from solution.

6. Flotation collectors may be classified into four general categories:

- A. Dithiols (e.g. xanthates, aerofloats)
- B. Cationic (e.g. alkyl amines)
- C. Fatty acids & soaps (e.g. oleic acid, sulphonates)
- D. Non-polar (e.g. kerosene, fuel oil)

For the following minerals indicate which type of collector (A, B, C, or D) would most likely be used to float that mineral.

Galena (PbS)

Sylvite (potash) (KCl)

Molybdenite (MoS₂)

Quartz (SiO₂)

Bituminous coal

Barite (BaSO₄)

(5 marks)

7. With the aid of sketches describe the operating principles and application of the following mineral processing unit operations. ANSWER ANY SIX OF THE FOLLOWING NINE TOPICS:

Dense (heavy) medium cyclone

Rod Mill

Hydrocyclone classifier

Jig

Flotation column

Lamella thickener

High tension (electrostatic) separator

Gyratory crusher

Spiral (Humphreys)

(30 marks)

Bonus Question (2 marks):

List two mineral commodities produced in Canada which are not beneficiated using froth flotation.

HAND IN THIS PAGE WITH YOUR EXAMINATION BOOKLET

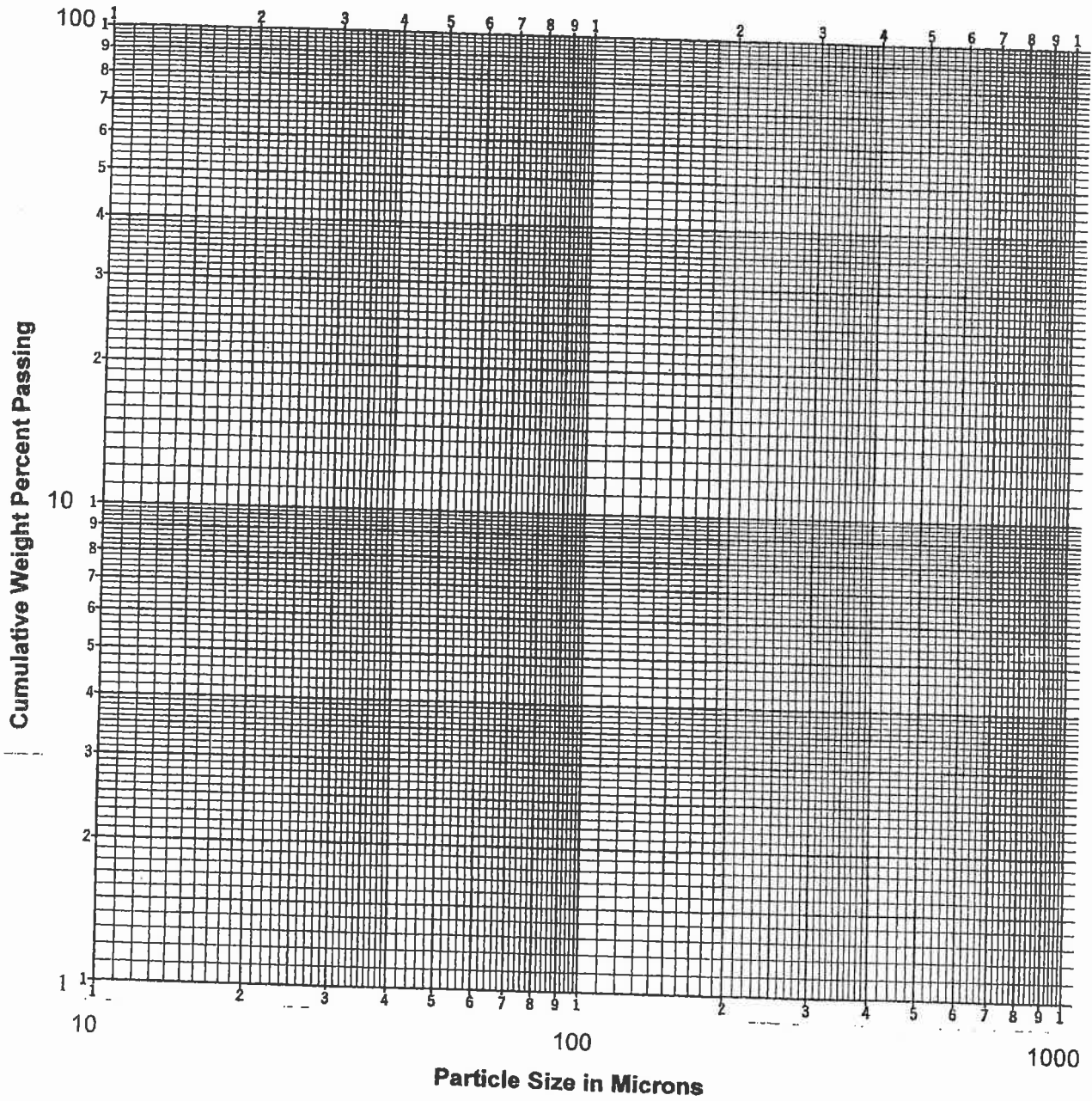


Figure 2. Size Analysis Graph for Problem 4